MC0166

HOSPITAL TECHNICAL MEMORANDUM

STEAM BOILER PLANT INSTRUMENTATION

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Steam Boiler Plant Instrumentation

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I. Scope

1. This memorandum expands the guidance on steam boiler plant instrumentation given to hospital authorities in the Appendix to R.H.B.(52)7/H.M.C.(52)7/B.G.(52)6. It makes recommendations for the instrumentation of new and existing steam boiler plants in hospitals so as to ensure efficient operation and optimum fuel economy. It also describes the various kinds of instruments available and gives some guidance on their installation and maintenance. The Appendix contains diagrams showing the positions of measuring points for typical Lancashire and Economic boiler plants.

II. Purpose of instrumentation

2. Instruments are essential for checking and correcting the operation of boiler plants to ensure that they are working at maximum efficiency. Given simple instructions from the hospital engineer, a trained stoker will be able to read the instruments and make any necessary adjustments to the plant controls to maintain optimum combustion efficiency despite fluctuating steam demands and variable fuel quality: this will repay many times over the cost of the instruments which enable him to do so.

3. The Appendix lists the instruments which should be adequate to check combustion efficiency and the general performance of boiler plant, and to provide all readings necessary to complete a boiler house daily log sheet based on that recommended in BS1374 for steam boilers. The customary boiler instruments and fittings (e.g. steam pressure gauges, water level gauges, etc.) are not included in the list.

4. Provided that the boiler plant is under the supervision of staff taking routine note of temperatures, pressures, water and fuel consumptions, etc., the more complicated and expensive types of recording and integrating instruments should not be needed, except for the measurement of CO_2 and steam.

5. Even when combustion control is achieved by an automatic system of adjustment to the dampers, fuel and air, instruments are required for periodic checks of the system.

6. The List in the Appendix also includes an electricity check meter and other meters to record consumption of electricity, fuel and water, which are needed for costing purposes.

III. Instruments

General

7. Instruments should be of a simple and robust design, of good quality and guaranteed accuracy within acceptable limits and of a type requiring the minimum of attention and maintenance in service. Indicating instruments should have large uniformly graduated scales, plainly marked for clear reading.

8. The type and quality of instruments selected should be suitable for the working conditions. The makers' full instructions on installation, operation and maintenance should be obtained with all instruments at the time of purchase and instruments should be installed in accordance with these instructions.

9. For the small and medium sized plant, a decision will have to be made on how many of the different types of instruments are justified; for example whether a steam meter is needed in addition to the feed water meter. A feed water meter measures the total water fed to the boilers, which gives an indication of the amount of steam issuing from the main steam stop valves plus the steam used for auxiliary equipment, that lost through the boiler safety valves, and the blow-down water. A steam meter gives a separate measurement of the steam issuing from the main steam stop valves, but this may not be necessary for small plant. Similar considerations may apply in relation to other instruments.

Draught gauges

10. Single and multiple diaphragm types of manometer with dial or edgewise scales for wall or panel mounting are recommended. Because it is important not to overstress the diaphragms, the maximum reading of this instrument should be some 50 per cent. higher than the highest pressure normally to be measured.

11. A three-way cock should be fitted to enable the gauge to be vented to atmosphere to check the zero reading.

12. The draught readings at the boiler furnace and outlet can be read on a single instrument fitted with suitable changeover cocks and indicating the point being measured.

Thermometers and pyrometers

13. Mercury-in-glass stem-type thermometers in protective casings and fitted into thermometer pockets are suitable for local readings up to 500°F, or higher if made of special glass. They are fragile and tend to be difficult to read. Mercury-in-steel thermometers are reliable and widely used for both local and distance readings; they are suitable for temperatures up to 1100°F.

14. Liquid expansion and vapour pressure thermometers, comprising metal bulbs wholly or partly filled with a suitable expansion or vapourising liquid and connected by fine bore capillary tubing to Bourdon type measuring elements, are suitable for temperatures up to 1100°F and can incorporate automatic ambient temperature compensation for extreme accuracy. Vapour pressure thermometers are sluggish in response to small temperature changes and liable to give uncertain registration in conditions of sudden cooling.

15. Constant volume gas thermometers are extremely accurate and suitable for temperatures up to 650°F.

16. Electrical temperature-measuring instruments are of two main types; resistance thermometers and thermo-electric pyrometers. Resistance thermometers may be of direct deflection or of null balance pattern; both require an external electricity supply. Null balance instruments are more sensitive but also more expensive. Both types are widely used for indicators and recorders. Resistance thermometers should not be used for temperatures above 1100°F.

17. Thermo-electric pyrometers (i.e. thermo-couples) are suitable for temperatures up to 2200°F, or higher if special metals are used in their construction. The cold junction of the thermo-couple should be located away from the heated zone and maintained at constant temperature; alternatively the instrument can be corrected for the actual cold junction temperature. The most satisfactory arrangement is to locate the cold junction inside the instrument with automatic compensation for cold junction temperature. Direct deflection pyrometers of both indicating and recording types are available; null balance instruments with potentiometric circuits designed to give automatic cold junction temperature compensation are also available both as indicators and recorders.

18. All types of electrical temperature-measuring instruments can easily be arranged for multi-point indication on one dial if required, either by manual or automatic selection (the latter in pre-determined sequence). There are limits to the number of recording instruments from which automatic selection can be arranged, but there is practically no limit to the number of points which may be served by one indicator with manual selection. The temperature-detecting elements of all instruments should be protected from corrosion by the gases.

19. Suction pyrometers are claimed to be the most reliable instruments for measuring flue gas temperatures: the thermo-couple is specially shielded from radiation effects and the flue gases are drawn at high velocity over the thermo-couple by means of a small fan.

20. Points of measurement for high temperature flue gases must be carefully selected, particularly with sheathed thermo-couples, since poor positioning—for example where the thermo-couple would be exposed to radiant heat from nearby surfaces or in stagnant areas which may not be representative of true gas temperatures—may give inaccurate temperature readings and misleading results in determining boiler plant efficiency.

Water meters

21. Notch weir meters are consistently accurate over a wide range of flow rates (down to $\frac{1}{30}$ full flow capacity) and their simple and reliable recording and integrating mechanism works under atmospheric conditions entailing little wear. The tank is rather bulky to accommodate as it must be large enough to ensure non-turbulant flow past the weir.

22. Mechanical meters of inferential and positive displacement type may be inserted directly into flow mains at any convenient point. Inferential type meters are less accurate at low flow rates and the smallest size of meter to meet the maximum duty required should therefore be chosen. Positive displacement meters maintain their accuracy down to very low rates of flow and are more suitable for boiler plant in hospitals where there may be long periods of low load. Pressure pulsations can seriously damage this type of meter; in boiler feed systems with reciprocating piston pumps the meter should be fitted on the suction side of the pumps.

23. Shunt type meters which combine the features of the mechanical and differential pressure (e.g. orifice plate and venturi tube) types are suitable for the larger boiler plant.

24. Meters for hot water flow are calibrated for a specific flow temperature and a correction factor must therefore be applied where the water temperature differs from the design temperature and readings in gallons require to be converted into weights.

Oil meters

25. Liquid flow meters of inferential or positive displacement types should be installed to register the total weight of liquid passed. For small rates of flow these should preferably be of positive displacement type. Standard types are usually guaranteed accurate to $\pm 2\%$ but specially designed meters of this type can be calibrated in position to limit the error to less than $\pm 1\%$ over a limited range of flow. For large rates of flow the inferential type is suitable and cheaper.

Steam flow meters

26. Differential pressure type meters are available in the form of indicators, or indicators and recorders combined. This type of meter is not damaged by heavy overloads, but will not register them. The minimum flow registered is usually limited to one eighth or one tenth of the maximum registered. The maximum flow to be measured should therefore be accurately

estimated. Meters register correctly for only one density of steam and a correction factor must be applied to the reading if the steam condition differs from the design condition. Since all differential pressure devices are adversely affected by local flow disturbances they should be inserted in a straight length of pipe, and steam flow control confined to the downstream side. To ensure that the pressure transmission pipes and the measuring element are kept full of water only, cooling chambers must be fitted to the pressure tappings on the steam line. All these instruments are normally provided with vent valves and a pressure equalising valve.

27. Shunt type meters are available and have the advantage that the maximum flow measured can be altered by changing the size of orifice plate. They will register overloads of up to 100% without damage and will also register down to one seventh full load with a guaranteed accuracy of ± 2 per cent. Accuracy is affected by the density of the metered fluid and by disturbed flow conditions upstream as in the case of differential meters. Shunt type meters are normally arranged to give a counter record only.

Solid fuel measurement

28. With small plants it will be sufficient to record the weight of fuel delivered to the plant or alternatively to record the number of barrow loads of assessed average weight delivered to the firing floor.

29. Larger plants usually incorporate in the coal handling equipment apparatus for continuous measurement on a weight or volumetric basis. Weights are recorded on an integrator type of counter. Measurement on a volumetric basis is satisfactory only for the particular type of coal for which the meter has been calibrated; changes in packing density, calorific value and moisture content will require adjustment of the counter mechanism or the application of a suitable correction factor to the meter reading. The decision whether or not to instal automatic coal metering must depend on the type of boiler-firing arrangement and the cost in relation to fuel consumed. This can rarely be justified for shell type boilers of less than 5,000lb./hr. evaporative capacity.

Gas analysis

30. It is most important that the sampling points for flue gas analysis should be in positions in which truly representative samples of the gas to be analysed will be obtained. Sampling should be continuous. The gas stream at the point of sampling should be turbulent and at high velocity. Points where the gas may be diluted by air infiltration through faulty ductwork should be avoided. For combustion control the sample of flue gas should be taken from the boiler outlet. For the determination of overall heat balance for the plant it should be taken near to or at the chimney where the final temperature is taken.

31. Portable flue gas analysers (e.g. Orsat) may be used for occasional readings on small plants and are useful on larger plants for checking the accuracy of fixed indicating or recording analysers.

32. For CO_2 measurement, indicating and recording equipment may be of chemical absorption or of thermal conductivity type. The analysing unit should be mounted in a position protected from vibration, free from draughts and ambient temperature variations. A number of analysing units connected to different sampling points can be used in conjunction with one measuring instrument.

Smoke detection and alarm

33. The simplest device is the Ringelmann Chart but determination of smoke density by this means is indefinite.

34. Fixed smoke-density metering equipment is also available, comprising light projecting and receiving elements in conjunction with a photocell connected to a suitable control unit and thence to an indicator or recorder. An audible alarm is incorporated in the control circuit arranged to sound when the measured obscuration exceeds the permitted limit. If a recorder is required in addition, one of the "event" type should be considered.

35. Where a smoke alarm and event recorder are fitted, each boiler outlet should be equipped with smoke viewing apparatus to facilitate identification of the offending unit when an alarm sounds.

IV. Siting of instruments and panels

36. The grouping of all instruments on a main control panel adds materially to the cost of the installation, not only in respect of the panel but also because of the extra transmission wiring or tubing required. While all instruments should be placed so as to be readily visible from the firing floor, some can economically be placed adjacent to the point of measurement; instruments for individual boilers can be mounted at the front of the boiler with draught gauges adjacent to boiler flue damper control gear. Only those instruments required for the control of the plant as a whole should be positioned centrally, either panel—or cubicle—mounted, and only if the size of plant warrants it.

V. Maintenance

37. Instruments will not retain their accuracy and reliability without regular servicing and adequate maintenance. Most boiler houses are hot and may be dusty and there can be vibration from machinery, conditions which do not favour delicate instruments. Regular attention is therefore essential.

38. There should be weekly checks of certain points, as well as regular servicing at longer intervals, say three months, or as recommended by the makers. Weekly checks should include the following items:

1. Zero readings	All instruments
2. Accuracy against a standard	All instruments
3. Sampling pipes and connections for leaks	CO_2 recorder. Draught gauges
4. Blow down connecting pipes to remove obstructions ...	Steam flow meters
5. Connecting pipes for leaks ...	Steam flow meters
6. Movement of chart and mechanism	All recorders
7. Inking ribbons or state of pens	All recorders
8. Condition of electrical connections	All electrical instruments

39. It is preferable for this regular servicing and maintenance of instruments to be carried out by a suitably trained hospital engineer rather than for it to be done under contract by a commercial firm. This is particularly so where, as is commonly the case, the instruments are of various types and makes. It may sometimes be convenient for one suitably trained engineer to undertake the work for several hospitals. Courses of instruction are sometimes arranged by the manufacturers.

40. If there is no hospital engineer available who is trained in instrument maintenance, it will be necessary to arrange a service and maintenance contract with a suitable firm or with the instrument makers. The contract should include provision for regular visits for items such as replacing worn parts and fittings, checking for corrosion, leakage, friction and wear, calibration, cleaning of working parts and cases, switches and contacts, mechanism timing, and examination of electric cables and circuits. The maintenance contractor should be required to submit a servicing and maintenance programme detailing precisely the work included in the contract price and indicating the type of emergency service available at extra cost.

References

BRITISH STANDARDS INSTITUTION

1. B.S.1041: Code for temperature measurement.
2. B.S.1042: Code for flow measurement.
3. B.S.1374: Log sheets for steam and hot water boiler plants.
4. B.S.1756: Code for the sampling and analysis of flue gases.
5. B.S.3048: Code for the continuous sampling of and automatic analysis of flue gases.
6. B.S.2740: Simple smoke alarms and alarm metering devices.
7. B.S.2741: Recommendations for the construction of simple smoke viewers.
8. B.S.2742: Notes on the use of the Ringelmann Chart.

MINISTRY OF HEALTH

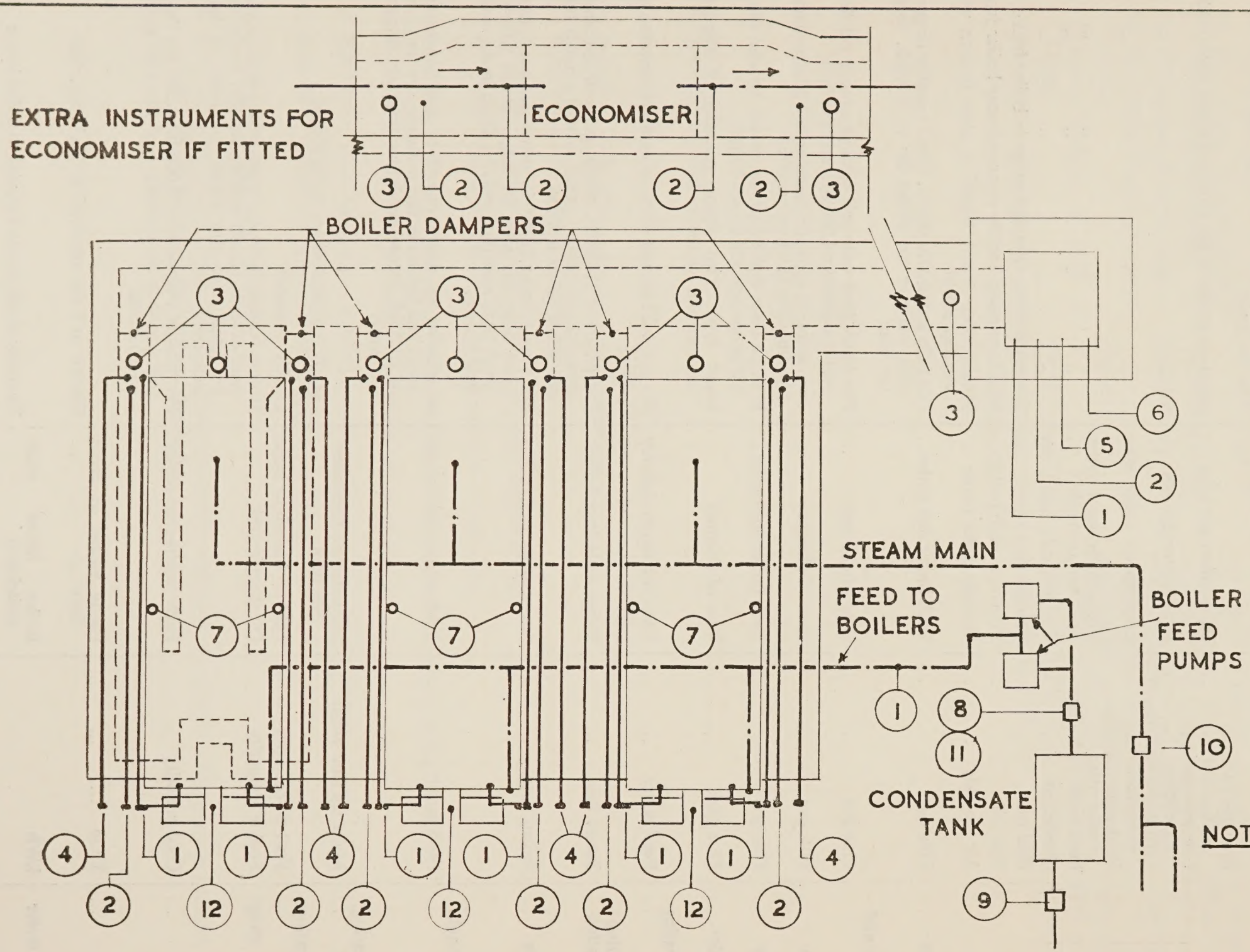
9. R.H.B.(52)7/H.M.C.(52)7/B.G.(52)6: The economical operation of essential engineering services in hospitals: plant operating control and instrumentation.

APPENDIX

Instrumentation for steam boiler plants in hospitals

(Customary boiler mountings and fittings are not included)

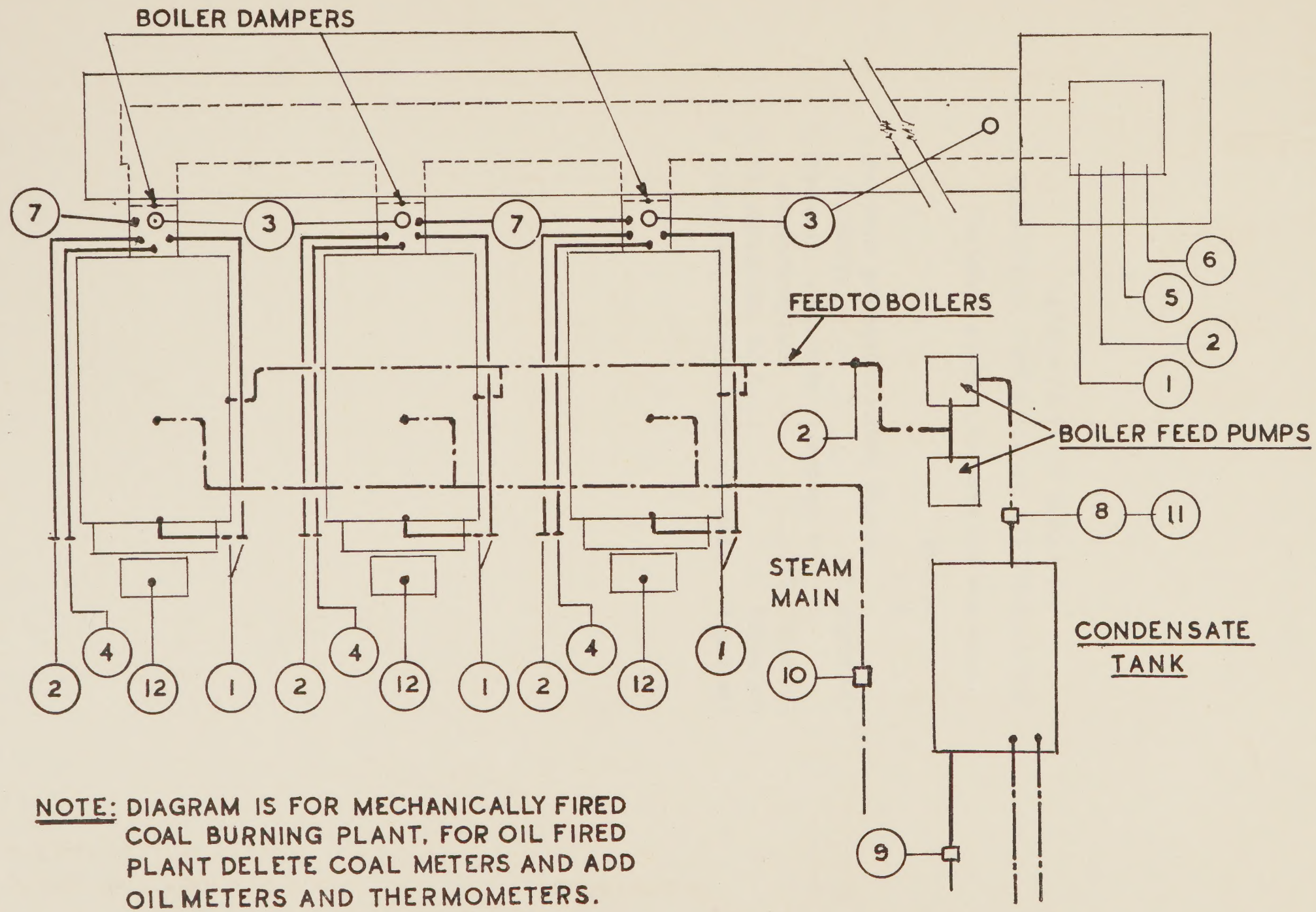
Instrument	*Measurement*	*Point of detection*	*Notes and directions*
Draught gauge ...	Flue gas leaving boiler...	Each boiler flue outlet...	Each side flue outlet for Lancashire boilers. Gauge at boiler front
	Air entering boiler ...	Over each furnace ...	Natural, induced and balanced draught systems
		Under each grate ...	Forced or balanced draught systems, solid fuel fired only
		Each burner plate ...	Oil fired boilers only. Gauge at boiler front
	Flue gas entering chimney	Base of chimney ...	Gauge in boiler house where easily visible
Thermometer	Flue gas leaving boiler...	Each boiler flue outlet...	Each side flue outlet for Lancashire boilers. Gauge at boiler front
	Flue gas entering chimney	At base of chimney ...	Distant reading type dial or edgewise gauge in boiler house
	Flue gas entering economiser	Economiser gas inlet ...	Dial type gauge locally mounted where easily visible
	Flue gas leaving economiser	Economiser gas exit ...	,, ,, ,, ,,
	Feed water entering economiser	Economiser water inlet	,, ,, ,, ,,
	Feed water leaving economiser	Economiser water outlet	,, ,, ,, ,,
	Feed water to boilers ...	Feed main to boilers ...	,, ,, ,, ,,
	Condensate	Condensate return main	,, ,, ,, ,,
	Fuel oil...	Storage tank outlet ...	Distant reading type dial gauge in boiler house
	Fuel oil...	Fuel oil to each boiler ...	Dial type gauge locally mounted near boiler front
	Air outside	Outside boiler house ...	Maximum-minimum liquid in glass pattern with weather shield
CO_2 indicator ...	Flue gas	Each boiler flue outlet...	For fully automatic plants. Hand sampler or portable analyser for plants up to 4,000lb. steam per hour
Co_2 indicator and recorder ...	Flue gas	Base of chimney ...	For hand fired coal and semi-automatic oil fired plants exceeding 4,000lb. steam per hour
Smoke alarm ...	Flue gas	Base of chimney ...	Two points if separate summer and winter stacks. Audible alarm where required
Smoke viewer ...	Flue gas	Each boiler flue outlet...	If more than one boiler connected to one stack. Periscope type for Lancs. boilers
Smoke recorder ...	Flue gas	Base of chimney ...	Event type. Two point recorder if separate summer and winter stacks
Meter, integrating hot water ...	Feed water	Feed suction or delivery main	See para. 22 on use of positive displacement type meter
Meter, recording and integrating...	Steam flow	Steam main from boilers	For plants of 10,000lb. steam per hour maximum demand and above, except where a notch tank recording meter is fitted
Flow indicator ...	Steam flow	Steam main from boilers	For plants under 10,000lb. steam per hour maximum demand. Also for larger plants where a notch tank recording meter is fitted in the boiler feed system.
Meter, notch tank, recording ...	Feed water	Feed pump suction main	Alternative to steam recording and integrating meter and hot water integrating meter for plants of 10,000lb. steam per hour maximum demand and over.
Meter, integrating, cold water ...	Make up feed water ...	Mains supply to condensate tank	Locally mounted where easily visible.
Meter, integrating, oil	Fuel oil quantity ...	Fuel oil branch to boiler	Locally mounted
Oil contents gauge	Fuel oil quantity ...	Oil storage tank ...	Distant reading hydrostatic gauge where oil storage tank exceeds 12,000 gallons. Smaller tanks may be fitted with dip sticks or local oil level indicators.
Coal meter ...	Coal quantity	Each mechanical stoker	For boilers evaporating 5,000lb. steam per hour and upwards. Integrating type fitted to mechanical stoker
Clock	Time	Easily visible at firing floor	Electric or 8 day mechanical clock, 8in. dial
kWh Check meter	kWh	Boiler house main switchgear	To meter all electricity supplied to boiler house



LIST OF INSTRUMENTS	
REF	INSTRUMENT
1	DRAUGHT GAUGE
2	THERMOMETER
3	FLUE GAS SAMPLING AND TEST POINT
4	CO_2 INDICATOR
5	CO_2 INDICATOR AND RECORDER
6	SMOKE ALARM AND EVENT RECORDER
7	SMOKE VIEWER
8	HOT WATER METER
9	COLD WATER METER
10	STEAM FLOW INDICATOR OR RECORDING AND INTEGRATING METER
11	NOTCH TANK METER ALTERNATIVE TO ITEM 8
12	COAL METER

NOTE: DIAGRAM IS FOR MECHANICALLY FIRED COAL BURNING PLANT. FOR OIL FIRED PLANT DELETE COAL METERS AND ADD OIL METERS AND THERMOMETERS.

INSTRUMENTATION FOR LANCASHIRE BOILERS



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